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# Effect of purple prairie clover (*Dalea purpurea* Vent.) hay and its condensed tannins on growth performance, wool growth, nutrient digestibility, blood metabolites and ruminal fermentation in lambs fed total mixed rations

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ABSTRACT

This study evaluated the effects of purple prairie clover (PPC, *Dalea purpurea* Vent.) hay and its condensed tannins (CT) on feed intake, growth performance, wool growth, nutrient digestibility, blood metabolites and rumen fermentation in lambs fed diets containing PPC and alfalfa hay. Alfalfa and PPC were harvested at similar growth stage, sun-cured to <12% moisture, and stored in a shed for 120 d. Thirty six individually fed lambs were randomly allocated into three groups and fed total mixed ration containing 40% (dry matter (DM) basis) of a pelleted barley grain based concentrate and 60% of alfalfa hay (AH), or 60% PPC hay (PH) or PH supplemented with polyethylene glycol (PH-p) for 77 d. Lambs were fed once daily and weighed bi-weekly. Faeces samples were collected in the 5th wk for 5 d to determine nutrients digestibility using acid insoluble ash as a marker. Lambs were slaughtered at the end of experiment to evaluate the carcass characteristics. Wool yield and quality were measured using a 10 cm dye band applied on d 0 and harvested on d 75. Blood samples were collected to analyze serum metabolites and antioxidant enzymes, and rumen fluid was sampled to analyze rumen fermentation products. Lambs fed PH had lower ($P < 0.01$) DM intake than AH or PH-p. Growth performance, wool growth parameters and carcass characteristics did not differ among diets. Lambs fed PH-p had greater ($P < 0.05$–$0.001$) DM, organic matter (OM), crude protein (CP), neutral detergent fibre (aNDF) and acid detergent fibre (ADF) digestibility than those fed AH, and greater ($P < 0.05$–$0.001$) CP, aNDF and ADF digestibility than those fed PH diet. Lambs fed

*Abbreviations:* ADF, acid detergent fibre; ADG, average daily gain; ADL, acid detergent lignin; AH, alfalfa hay; AIA, acid insoluble ash; ALB, albumin; ALKP, alkaline phosphatase; ALT, alanine aminotransferase; BUN, blood urea nitrogen; BW, body weight; Ca, calcium; CAT, catalase; CHOL, cholesterol; CP, crude protein; CREA, creatinine; CT, condensed tannins; DM, dry matter; DMI, dry matter intake; FE, feed efficiency; GLOB, globulin; GLU, glucose; GSH-Px, glutathione peroxidase; LRDC, Lethbridge Research and Development Centre; MDA, malondialdehyde; N, nitrogen; aNDF, neutral detergent fibre; OM, organic matter; P, phosphorus; PEG, polyethylene glycol; PPC, purple prairie clover; PH, purple prairie clover hay; PH-p, PPC hay along with polyethylene glycol; SOD, superoxide dismutase; TAC, total antioxidant capacity; TBIL, total bilirubin; TMR, total mixed rations; VFA, volatile fatty acid.

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PH exhibited greater apparent total tract digestibility of DM ($P < 0.05$) and OM ($P < 0.05$) and tended ($P = 0.059$) to have greater CP digestibility compared to those fed AH. Lambs consuming PH diet had lower ($P < 0.05$) blood urea nitrogen and creatinine than AH and lower ($P < 0.05$) blood glucose and urea than PH-p, but greater ($P < 0.01$) total antioxidant capacity and catalase activity than AH diet. Lambs fed PPC CT had lower ($P < 0.05$) concentrations of ammonia, total VFA, propionate, *iso*-butyrate, *iso*-valerate and protozoa. It was concluded that PPC hay had greater nutritive value to alfalfa hay owing to its greater DM, OM and protein digestibility, but did not improve lamb growth.



## 1. Introduction

The low cost of grain and the high feed efficiencies of grain diet have resulted cattle production in North America concentrating in large industrial scale production systems. However, the confined feeding of large-scale and high-energy grains to beef cattle is faced with increasing challenges in terms of animal health and welfare, environmental pollution and food safety (Owens et al., 1998; Vasconcelos and Galyean, 2008). Consequently, there is a need to increase the use of forages in cattle production systems that maintain cattle health, are economically sustainable and reduce negative environmental impacts.

Alfalfa is by far the most important forage in North America because of its high yield, adaptability, high nutritive value and ability to sustain rates of gain that are comparable to those obtained in feedlots (Popp et al., 2000). However, feeding alfalfa to cattle has limitations as it frequently causes bloat. In contrast, forages that contain condensed tannins (CT) are considered bloat-safe as the CT bind to proteins upon chewing and ruminating, preventing the formation of the proteinaceous, gas-trapping foam associated with legume bloat (Waghorn and Jones, 1989; McMahon et al., 1999). In addition, CT at medium concentrations (40–50 g extractable CT/kg dry matter (DM)) have been found to improve protein utilization by reducing protein degradability (Wang et al., 1994b; Waghorn et al., 1999), resulting in increased productivity of animal feeding temperate forages with high protein content (Wang et al., 1996a,b; McMahon et al., 1999).

There are a variety of forages grown in North America that contain CT with vastly different chemical properties (McAllister et al., 2005; Berard et al., 2011). Purple prairie clover (PPC; *Dalea purpurea* Vent.) is a native legume widely distributed in prairie region of North America. It is considered to be an important palatable forage with high nutritive value for ruminants (Posler et al., 1993; Schellenberg and Banerjee, 2002). The CT in PPC possess strong anti-*Escherichia coli* and anti-*E coli* O157:H7 activity as demonstrated by numerous *in vitro* and *in vivo* studies (Liu et al., 2013; Wang et al., 2013; Jin et al., 2015; Huang et al., 2015).

However, the nutritive value and feeding value of PPC for ruminant livestock has rarely been determined. Jin et al. (2012) reported CT concentrations in PPC up to 94 g/kg DM had minimal impact on *in vitro* DM degradability. Huang et al. (2015) showed that CT at 35–36 g/kg DM in green-chop PPC decreased protein digestibility, but did not affect organic matter (OM) or fibre digestion in lambs fed PPC-alfalfa mixture. Because legume forage is usually preserved as hay to be used in intensive feedlot industry, it is important to know the nutritive and feeding value of PPC hay to evaluate the feasibility of PPC as a potential forage source.

The objective of this study was to assess the effects of PPC hay and its CT on growth performance, wool growth, nutrient digestibility, blood metabolites and rumen fermentation in lambs fed diets containing PPC or alfalfa hay.

## 2. Materials and methods

This experiment was conducted between December 2015 and February 2016 at the Lethbridge Research and Development Centre (LRDC), Lethbridge, Canada. All lambs used in this study were cared for according to guidelines set by the Canadian Council on Animal Care (CCAC, 2009) and the protocol was approved by the LRDC Animal Care Committee.

### 2.1. Forage preparation

Pure stands of alfalfa (cv. AC Longview; mid- to full-bloom stage) and PPC (common seed; full-bloom stage) were harvested from irrigated plots of the Swinton silt loam soil at the LRDC. The plots had been established for two years and were cut using a forage harvester (John Deere 6610; Moline, IL, USA), sun cured in the field to <12% moisture, baled in approximately 20 kg square bales ($90 \times 50 \times 30$ cm) and stored in an enclosed shed at ambient temperature for 120 d. Prior to feeding, both PPC and alfalfa hay were mechanically chopped to ≈10 cm lengths using an Agri-Chopper (Valmetal, QC, Canada) and stored in a closed shed. Thereafter, hays were sampled weekly starting from the 1st week of lambs being fed chopped hays for chemical analysis (Table 1). The samples were taken from top, middle and bottom of haystack which were then composited as a single sample at each sampling time.